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ABSTRACT

This paper has three purposes. First, it places in scientific perspective the growing acceptance in educational administration research of alternative methods to empiricism by an explication of chaos theory and its assumptions. Second, it demonstrates that chaos theory provides a scientific basis for investigation of complex qualitative variables by focusing on individual and peculiar properties of a system. Finally, it synthesizes the major assumptions of ethnomethodology and phenomenology that have been applied to educational administration and shows how these assumptions and the assumptions of chaos theory are compatible. It also demonstrates how chaos theory thus provides a scientific basis, but not justification, for alternative means of looking at reality. (LMI)

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# Chaos Theory: A Scientific Basis for Alternative Research Methods in Educational Administration

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There are three purposes of this paper: first, to place in scientific perspective the growing acceptance in educational administration research of alternative methods to empiricism by an explication of chaos theory and its assumptions; second, to demonstrate that chaos theory provides a scientific basis for investigation of complex qualitative variables by focusing on individudual and peculiar properties of a system; lastly, to synthesize the major assumptions of ethnomethodology and phenomenology which have been applied to educational administration and indicate how these assumptions and the assumptions of chaos theory are compatible and how chaos theory thus provides a scientific basis but not justification for alternative means of looking at reality.

## Introduction

The past ten years in the educational administration field have demonstrated a turbulence over the predominance of empiricism as "the" research methodology. Initial debates focused upon arguments against empiricism. These debates have subsided in intensity as alternate research

paradigms were presented and quietly incorporated into the literature.

Recent publications regarding educational administration theory and research have presented radical concepts such as reflective practice (Osterman, 1990), case studies as a means to understand educational administration practice (Kowalski, 1991; Lipham, Rankin, and Hoeh, 1990), and educational leadership as elaborated upon through phenomenology (Mitchell, 1991). While the new concepts in educational administration research and practice were being incorporated into the literature, albeit not with full acceptance, a similar revolution was apparent in the physical sciences.

Chaos theory has overturned the basic concepts of how the natural world is ordered. Formally called nonlinear science or dynamical systems theory, Chaos theory can be defined as "nonrandom behavior that cannot be accurately predicted on a long-term basis" (Babner, et. al., 1989, p. 2). Although chaotic systems appear to be random, they are really constrained through repeatable patterns.

Many researchers who found linearity unable to provide answers to basic questions of prediction and

patterning have seized upon this concept of non-linearity. Chaos theory has been applied to economics (Bailey, 1988; Sterman, 1988; Drucker, 1989), to political science (Peterson, 1985), and to astronomy and atomic fusion (Chaos, 1985). The field of medicine has incorporated chaos theory into investigations of genetics (Pool, 1989), brain disorders (McAuliffe, 1990), epilepsy (Peterson, 1983), body rhythms (Pool, 1989), and measles outbreaks (Pool, 1989). Likewise, the field of education has demonstrated interest in non-linearity as chaos theory has been applied to information processing (Bower, 1988), cognitive development (Lindsay, 1991), the knowledge base in teacher education (Rockler, 1990-91), and educational administration (Griffiths, Hart, and Blair, 1991).

## Explication of Chaos Theory

Why is chaos theory so compelling to members of diverse fields of knowledge? Chaos theory acknowledges that linearity is unable to explain all of natural or man-made functions. Chaos theory is based on the assumptions of sensitivity to initial conditions, the apparent lack of order in chaotic

systems, the underlying order maintained by strange attractors, and the search for patterns.

Sensitivity to Initial Conditions

Empiricism is based upon Newton's concept that given an approximate knowledge of a system's initial conditions and an understanding of natural law, one can calculate the approximate behavior of a system (Gleick, 1987). This assumption has lead to the search for precise data which would in turn produce precise predictability. Gibbons (1988) synthesizes this concept by stating that empiricism is an attempt "to explain complex behavior with linear equations, where a given input produces a proportionate output" (p. 10).

The discovery of chaos theory was derived from this principle in a search to discover which conditions produce specific types of weather. This research, according to Gleick (1989), produced results which negated Newtonian assumptions:

> Tiny differences in input could quickly become overwhelming differences in output - a phenomenon given the name "sensitive dependence on initial conditions." In weather, for example, this translates into what is known as the Butterfly Effect - the notion that a butterfly stirring the air today in Beijing can transform storm systems next month in New York. (p. 47)

This concept of sensitivity to initial conditions presents an argument against and a solution to the problem of quantification necessary for empirical research. Empiricism assumes that all human behavior can be approximately quantified and eventually predicted. Chaos theory's discovery was that when initial conditions are changed by even the slightest degree, differences increase over and over again with each moment and eventually lead to two drastically different pictures of the same process (Taubes, 1984).

Because of the imperfection of measurement, ". . . predicting the final result of any chaotic pattern is impossible, simply because measuring the initial conditions with infinite precision is impossible" (Taubes, 1984, p. 32). This concept is assumed in empiricism in that what is tested is an hypothesis and the end result of much research does not lead to absolute prediction but only to the identification of tendencies in specific situations.

Because of this assumed inability to measure initial conditions, does chaos theory further assume that all in the physical world is random? No. Chaos theory does not seek to explain the random error that is a result of pure chance but does seek

to explain the influence of the innumerable uncontrolled variables that determine an experimental result. The results of experiments with chaotic systems may appear to be random because, according to Jensen (1969), we often observe only a single realization of the dynamical process evolving from a specific initial condition. Thus, chaos theory does not posit reality as chaotic and unpredictable, but as unpredictable due to scientists' inability to precisely measure all initial conditions and due to reality being inherently ordered despite appearances to the contrary.

Strange Attractors

An important difference between a random system and a chaotic system is the existence of a strange attractor (Butler, 1990). Underlying the apparent lack of order in a chaotic system is a bounded pattern. That which attracts the system toward this pattern is called the strange attractor. NOVA (1989) explains the strange attractor as the combination of order and chaos within a fixed boundary. Within that boundary, behavior is totally unpredictable due to sensitivity to initial

conditions which are unique to specific sets of variables. This boundary caused by the strange attractor negates the possibility of randomness because, according to Butler (1990), even though the pattern never reaches equilibrium in the standard sense, it also never leaves the strange attractor and, therefore, is not unstable.

The reason for the development of this bounded chaotic pattern is the iteration or feedback involving the continual reabsorption or unfolding of what has come before (Briggs and Peat, 1989). As Hayles (1990) explains, "When the function is strongly nonlinear, small fluctuations in the data are not smoothed out as iteration proceeds. Rather, they are magnified through a cascading series of bifurcations" (pp. 14 and 15). Within the chaotic bounded pattern, the same patterns continuously reiterate as in a kaleidoscope. Hence, the inapparent minute dissimilarities between initial conditions of seemingly similar systems are magnified over time by iteration and cause the chaotic pattern for each system to be unique. According to Briggs and Peat (1989), ". . . nonlinear solutions tend to be stubbornly individual and peculiar" (p. 24).

## Holistic Systems

Chaos theory seeks to understand underlying patterns of behavior. While empirical investigation seeks to determine how the parts affect the whole, chaos theory endeavors to understand the whole pattern, which is composed of ever-changing parts. Briggs and Peat (1989) clarify this holistic view of chaos theory:

> Complex systems - both chaotic and orderly ones - are ultimately unanalyzable, irreducible into parts, because the parts are constantly being folded into each other by iterations and feedback. Therefore, it's an illusion to speak of isolating a single interaction between two particles and to claim that this interaction can go backward in time. Any interaction takes place in the larger system and the system as a whole is constantly changing, bifurcating, iterating. So the system and all its parts have a direction in time. (pp. 147-48)

Thus, complex systems must be viewed as a whole because all parts and iterations, however apparently insignificant, interact with all other parts and iterations. Complexity cannot be reduced to a simpler form; complexity must be understood and admired for its complexity.

## Summary of Chaos Theory Assumptions

Chaos theory is a scientific method which seeks to discover the underlying pattern of apparently

disordered behavior. It is revolutionary because, according to Gleick (1989), chaos theory has radically transformed the way scientists think about their universe, the way they perceive the complexity that always exists in their slices of life. Crutchfield, et al. (1986) view chaos theory as a seeming paradox in that

> Chaos is deterministic, generated by fixed rules that do not themselves involve any element of chance. In principle the future is completely determined by the past, but in practice small uncertainties are amplified, so that even though the behavior is predictable in the short term, it is unpredictable in the long term. (p. 46)

The assumptions of chaos theory for complex chaotic systems may be summarized in the following manner:

1. Even slight differences in initial conditions can cause extensive differences in outcomes.
2. Complexity prevents the ability to precisely quantify all initial conditions.
3. Prediction can be made only on a short term not long term basis.
4. Complex systems display a bounded pattern of behavior.
5. The strange attractor causes this bounded pattern and negates random behavior.

6. Iteration causes magnification of system dissimilarities and forms the pattern.
7. There can be no valid generalization in the long-term about complex systems.
8. Complex systems are to be viewed as wholes and not as isolated parts.

Chaos theory seeks to understand those aspects of reality that have eluded scientific investigation because they have intervened between those variables which were apparently isolated. Isolation of parts is contrary to chaos theory in that parts have no meaning outside their interrelationship within the whole and thus chaos theory shifts "attention from the quantitative features of dynamical systems to their qualitative properties" (Briggs and Peat, 1989, p. 14).

## Alternative Paradigms in Educational Administration

At a time when education is being closely scrutinized as to its outcomes and methods and while chaos theory is emerging as a valid research methodology in the physical sciences, some educational administration theorists question the results of historically basing their theoretical position under the empirical perspective. Two

paradigms presented as alternatives to empiricism are ethnomethodology and phenomenology with their inclusive case study and reflective practice methodologies. A comparison and contrast of these three alternative paradigms will clarify the apparent differences.

Reality and Order

The positivistic paradigm adheres to the assumptions that knowing of objective reality in an objective manner. Truth occurs when what is known corresponds to objective reality. The empirical researcher assumes that subjectivity in knowledge does not lead to truth because between the object known and the knower, there exists no relationship; the subjectivistic paradigms of phenomenology and ethnomethodology, however, do posit such a relationship. While both are based on the epistemological premise of the interaction between the object known and the knower, each paradigm defines epistemological interaction differently. The phenomenologist holds that objective reality is not defined by correspondence but by the interaction of the individual person's experience and that individual's ability to reason. Neisser (1966)

explains this relationship: "What we know about reality has been mediated, not only by the organs of sense but by complex systems which interpret and reinterpret sensory behavior" (p. 3). Thus, the adherent to phenomenology upholds the position that knowledge is relative to individual experience and reasoning.

While ethnomethodological theorists also maintain a subjectivistic posture, as Schutz (1966) indicates, an individual interpretation of objective reality is considered insufficient by ethnomethodological theorists to obtain the truth because "only a very small part of my knowledge of the world originates within my personal experience. The greater part is socially derived" (p. 9). The ethnomethodological theorist holds that truth is dually defined: first, by correspondence to objective reality and, second, by its relation to social interaction. Since the ethnomethodologist is unable to arrive at all of truth and the truth that is discovered is relative to the situation and social interaction within that situation, reality can be known only partially and only its social context.

At the philosophical level of definition of reality, the three theoretical positions focus on the orderliness of reality and the means by which the ultimate truth will be obtained. The empiricist posits an inherent order in objective reality that can be discovered in an objective manner. The discovery of such order will produce laws or principles by which scientists can understand the world.

Phenomenologists and ethnomethodologists posit reality as being in a constant state of flux. Such inherent change is ordered, but not inherently because order is imposed by the human mind. Phenomenological theorists hold that reality is ordered by the logic of the human mind and to discover such order, one must learn what perceptions the individual holds about reality (Silverman, 1971). Burrell and Morgan (1979) clarify that the ethnomethodological theorist views the ordering of a changing reality as imposed by social interaction. The focus of knowledge thus becomes the generalized social rules which are agreed upon in specific situations.

Alternative Methodologies

Empiricists place primacy on objective reality being known only in an objective manner. By means of induction, specific controlled instances of reality are investigated and the results of such study are generalized into theories which can lead to laws. Bates (1980) explains the empirical method of research: "The aim of scientific investigation is to understand how the construction of reality goes on at one time and place to compare with what goes on in different times and places" (p. 7). Such extrapolation of the specific to the general is possible because of empiricism's assumptions of underlying laws of reality which the researcher seeks to discover.

In contrast, phenomenology and ethnomethodology are based upon the assumption of the existence of objective reality which can be known only in a subjective manner. In order to understand the specifics of reality, the case study method is utilized because it focuses on situation-specific instances of reality. Because of the differences in their epistemological assumptions, phenomenology focuses on the perceptions of the individual, while

ethnomethodology focuses on social interaction and the resulting social rules.

Inherent in the differences in methodologies utilized by the differing theoretical positions is the underlying objective versus subjective debate. Empiricism posits that the general can be derived from the specific, while ethnomethodological and phenomenological methodology posit that the study of the whole context leads to an understanding of the specific. This basic difference between the objective and subjective positions is most noted in the distinctive treatment of error variance by empirical and case study methodologies. For the empiricist, Schutz (1966) defines error as "the product of chance which is the influence of the innumerable uncontrolled factors determining an experimental result" (p. 150). According to Louch (1966), advocates of case study methodology hold that such acceptance of generalizations which ignore deviations does not reflect true reality: "If laws are treated as generalizations, they are not conclusively verifiable, for they cover any possible case of a sort, and thus include cases beyond those for which verification has been offered" (p. 7). The fundamental difference between these two

methodologies is thus seen to be that empiricists search for laws which cover all areas of human behavior and which will enable people to control and predict human behavior, while advocates of case study methodology adhere to the position that this search is futile owing to the intervention of specific individual and social factors, and, instead, seek to explain the meaning of human behavior.

Summary of Alternative Paradigm Assumptions

Phenomenology and ethnomethodology are founded upon similar assumptions with the former focusing on the individual and the latter on social interaction. The assumptions of both paradigms may be summarized as follows:

1. Both paradigms adhere to the existence of an objective reality.
2. Both view reality as defined by understanding and interpretation either by the individual (phenomenology) or by social interaction (ethnomethodology).
3. Both posit reality as in a constant state of flux which can only be ordered through individual or societal interpretation.

4. Both adhere to case study methodology of situation-specific instances of reality.
5. Both oppose generalization due to the uniqueness of variables within each instance of reality.
6. Both seek to understand the underlying patterns of an instance of reality and view the parts as merely those variables which comprise the whole.

## Comparison and Contrast Between Assumptions of Chaos Theory, Ethnomethodology and Phenomenology

In reviewing the assumptions of chaos theory, ethnomethodoly, and phenomenology, it is apparent that there is no precise correlation among these assumptions, but there are similarities. Both ethnomethodology and phenomenology posit subjective knowledge of reality, while chaos theory maintains that reality can be known objectively if quantification of initial conditions can be precise -- but only on a short term basis. However, chaos theory does provide an understanding of the limitations of empiricism and does open the door for alternative ways to view and study reality.

Concern about the limitations of empiricism is most apparent in the social sciences. Complex systems with multiple intervening variables, often

unknown to the researcher, can corrupt an experiment and cause both prediction and generalization to be ultimately undiscovered. As Lindsay (1991) clarifies:

> Linear models work well when the goal is to study a system's behavior under controlled conditions. However, when the goal is to describe a system's behavior in its natural environment, the outcome is much less satisfactory. (p. 1)

Chaos theory confirms the inability of empiricism to isolate all variables in a complex system because of the system's sensitivity to initial conditions. Sterman (1988) indicates the effects of systems complexity upon empirical methodology:

> Aggregate data sufficient for strong empirical tests simply do not exist for many of the most important social systems. Social systems are not easily isolated from the environment. The huge temporal and spatial scales of these systems, the vast number of individual actors, considerations of cost, and ethical concerns make controlled experiments on the systems themselves difficult at best. (p. 172)

Ethnomethodology and phenomenology also seek to understand these elusive variables by retrospective methodologies -- case study and reflective practice. Both methods acknowledge that all variables which influence the outcome cannot be known under initial circumstances, but can be deduced after the outcome has been discovered.

Both ethnomethodology and phenomenology posit the impossibility of prediction and, therefore, do not seek to predict any behavior. Prediction is replaced by understanding. Chaos theory likewise has demonstrated that prediction is almost impossible because of the inability to precisely measure all the variables which influence a system. Chaos theory maintains that precise measurement is lacking due to mathematical limitations -- a position which ethnomethodologists and phenomenologists have long held. Magoon in 1977 saw that the goal of scientific inquiry into human behavior may very well change from prediction to explanation and this explanation of human behavior is what chaos theory, ethnomethodology and phenomenology view as the goal of research.

Unlike empirical research which seeks to isolate the parts of a system in order to understand the whole, chaos theory seeks to understand the whole system as a whole. According to Briggs and Peat (1989), the questions to be answered are: "What does the whole look like as it moves and changes? How does one whole system compare to another" (p. 84)? Ethnomethodology and phenomenology also emphasize a holistic view of a

system as intrinsic to understanding. All three paradigms posit the whole as being greater than the sum of its parts.

Chaos theory assumes the uniqueness of apparently similar systems due to the sensitivity to initial conditions which in complex systems are rarely equal in affecting system behavior. Ethnomethodology and phenomenology also posit the uniqueness of systems due to situation-specific variables. Because of this uniqueness, generalization is not possible, but understanding can be gained through reflective practice and development of the case study.

## Conclusion

The discovery and application of chaos theory does not justify specific alternative research paradigms in educational administration such as ethnomethodology and phenomenology. However, the basic assumptions of chaos theory can be seen to be compatible with these alternative paradigms because in complex systems:

1. Isolation and quantification of all variables which affect a system is impossible but can be

known through retrospective methodologies of case study and reflective practice.

2. The goal of research is understanding of complex patterns.
3. The whole system is greater than the sum of its parts.
4. Apparently similar systems are found to be unique.

Perhaps chaos theory has become so fascinating and compelling because it does present an alternative way to study reality and also confirms and explains why empiricism is unable to quantify, predict and generalize about complex systems. Chaos theory provides an expansion of means by which reality can be known and, perhaps, will allow greater tolerance for alternative paradigms in educational administration.

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